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Prospective Pre-School Teachers' Views on the Nature of Science and Scientific Inquiry

SELCUK AYDEMIR, MUSTAFA UGRAS, OZNUR CAMBAY and AYGUN KILIC

Abstract

This research has examined prospective preschool teachers' views on the nature of science and scientific inquiry. The research was conducted with 54 prospective preschool teachers. Two data collection tools were employed: "Views on Nature of Science" (VNOS-C) to determine prospective pre-school teachers' views on the nature of science and "Views about Scientific Inquiry Questionnaire" (VASI) (Lederman et al., 2014) to explore their opinions about scientific inquiry, and individualized semi-structured interviews were administered to each participant in order to determine the conceptual meanings of the prospective teachers related to the nature of science and scientific inquiry. Research findings revealed that prospective preschool teachers have inadequate views and conceptual errors with regards the nature of science and scientific inquiry. Additionally, a statistically significant difference was identified between prospective preschool teachers' views in terms of nature of science and scientific inquiry ($r=.795$, $p<.05$).

Keywords: nature of science, scientific inquiry, prospective pre-school teachers.

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Introduction

The preschool period, which is the basis of life, is a period when children are emotional and sensitive to their surroundings, their imaginary world is vast, and they try to understand the reasons and results of situations they encounter through asking questions (Abbetudo & Beth, 2002, as cited in Ulutas & Saglam). It is also a time when they significantly develop both physically and mentally and when they direct their attitudes towards their own skills (Millî Egitim Bakanligi [Ministry of National Education], 2013). During the pre-school period, the experience that children gain affects their interest in learning, attitude and success as their brains develop so fast and their sense of discovery is intense, and therefore the events happening in their environment significantly affect their development and motivation to learn (Millî Egitim Bakanligi [Ministry of National Education], 2013). Therefore, it is of great importance for children to develop positive attitudes towards science and scientific inquiry during the pre-school period in terms of raising scientifically literate individuals and hence the increase in the potential of scientists for further education.

Achieving this basic objective can only be possible with qualified training environments. Qualified education can be provided by qualified teachers who will ensure meaningful and permanent learning through the development of effective educational settings (Kaya, 2010; Millî Egitim Bakanligi [Ministry of National Education], 2009; Turk Egitim Dernegi [Turkish Education Association, TED], 2009). Since the teachers who are in constant interaction with the students are regarded as the most significant factor affecting student's success and quality (Hanuscin, Lee, & Akerson, 2010), there is a significant relationship between teacher quality and student achievement (European Parliament, 2014; Turk Egitim Dernegi [Turkish Education Association, TED], 2009). Thus, there is a serious sense of responsibility for pre-school teachers to educate scientifically literate individuals and therefore the scientists of the future. In order for preschool teachers and prospective teachers to fulfill this important task, they must primarily be scientifically literate individuals. The concept of "scientific literacy," which is the most important aim of education programs in many countries, especially in the USA and Europe, was first defined by the Council of Higher Education (YOK) in Turkey as a way that individuals recognize the natural world, understand concepts and principles of science and think scientifically (Yildirim, 2005). A scientifically literate person is familiar with how science, technology and society interact with one another and uses his/her knowledge effectively in daily life (American Association for the Advancement of Science [AAAS], 1990; National Research Council [NRC], 1996). Many reform documents are based on the premise that a science-literate person must understand and assimilate the nature of science and scientific inquiry at a sufficient level (Lederman, Abd-El Khalick, Bell, & Schwartz, 2002).

Being acquainted with the nature of science and scientific inquiry potentially contributes to the increase of the learners' achievement and attitude related to science (American Association for the Advancement of Science [AAAS], 1989, 1993; National Research Council [NRC], 1996). In other words, a science literate person is defined as a person who has the knowledge and skill to absorb the nature of science and scientific inquiry, and to make effective decisions in personal and social matters as well as producing solutions (Aydemir, 2012). A functional understanding of the nature of science and scientific inquiry by teachers is regarded as a prerequisite to achieving this main purpose, which is documented in the various reform documents (Lederman, 1998). Preschool teachers and those who are

prospective must, therefore, be science literate individuals in order to raise individuals in that way. By extension, it is notable to distinctively examine the views of prospective preschool teachers regarding the nature of science and scientific inquiry.

Nature of Science

There is no common opinion among international education institutions, science educators, science philosophers, science historians and scientists about what the nature of science means. They have nonetheless achieved a consensus about the fact that understanding the nature of science is a perennial objective of science teaching (Bell, Lederman, & Abd-El Khalick, 2000; DeBoer, 2000). The nature of science refers to the epistemology of science in general, or beliefs and values specific to the nature of the development of scientific knowledge (Lederman, 1992). On the other hand, McComas, Clough, and Almazroa (1998) defined the nature of science as a mixture of features of various social sciences including science psychology, science history, and science sociology that is conflated with research from mental sciences such as psychology in explaining numerous issues such as what science is, how science advances, how scientists work as a social group, how society's culture and structure direct scientific efforts, and how it reacts. In general terms, the nature of science is a hybrid field blended with various aspects of science such as history, philosophy, sociology and psychology (McComas, Clough, & Almazroa, 2000).

Although no consensus virtually exists among the philosophers, historians, sociologists and science educators on a certain definition of the nature of science, the variety of views have been eventually clustered on eight main factors. These are; (1) scientific knowledge is tentative (subject to change), (2) empirically based (depending upon and/or originated from observations of the natural world), (3) theory-laden, that is, subjective, (4) including multiple methods, (5) influenced by sociocultural values, (6) partly the product of human inference, imagination, and creativity. The two additional significant aspects are; (7) the distinction between observations and inferences, and (8) the functions and relations between scientific laws and theories (Abd-El-Khalick, Bell, & Lederman, 1998).

Scientific Inquiry

Like the nature of science, the definition and content of scientific inquiry has been debated in terms of science education for decades (Schwartz, Lederman, & Lederman, 2008). Considering science education in particular, various definitions are made based on multiple research methods in science related to science as inquiry (Bybee, 2000).

The National Science Education Standards (NSES) describes scientific inquiry in more general terms as explanations of what scientists make to understand the natural world in different ways and based on the evidence they have gained from their studies. Scientific inquiry is also expressed as activities that learners perform in order to develop scientific ideas and scientific knowledge along with understanding how scientists work to understand the natural world. Scientific inquiry refers to the characteristics of the process by which scientific knowledge is developed (Schwartz et al., 2008).

Some international education institutions (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 2000), science educators (e.g., Chinn & Malhotra, 2002; Flick & Lederman, 2004; Osborne, Ratcliffe, Collins, Millar, & Duschl, 2003; Windschitl, 2004) and researchers (e.g.; Dunbar, 2001; Knorr-Cetina, 1999)

have offered definitions related to scientific inquiry, and the main aspects of the nature of scientific inquiry (NOSI) that are deemed as appropriate and important for science education. Even though these aspects have not recently been revealed, they are still consistent with those put forward by Joseph Schwab (Schwartz et al., 2008). The general aspects of the scientific inquiry hold that; a) Scientific inquiry starts with a question, b) Scientific inquiry includes multiple methods, c) Scientific inquiry process is managed by research questions, d) Scientists who conduct the same procedure may encounter with different conclusions, e) Research procedure may affect the results of the research, f) The research results should be consistent with the obtained data, g) The difference between the data and the evidence, and (h) The explanations of the research results are a combination of the obtained data and the literature (Lederman et al., 2014). The current research examines prospective preschool teachers' views regarding the nature of science and scientific inquiry within the framework of these main aspects described.

Upon analyzing the national and international literature, it can be seen that few studies have been conducted on the views of in-service and prospective preschool teachers regarding the nature of science and scientific inquiry, and in general, some studies have analyzed prospective preschool teachers' views on science or the nature of science (e.g., Bayir & Gunsen, 2014; Senel & Aslan, 2014; Turgut, Es, Bozkurt Altan, & Ozturk Geren, 2016). This current research is therefore paramount in examining prospective preschool teachers' views on both the nature of science and scientific inquiry in order to increase the potential of qualified scientists.

The overall aim of this current research is to explore prospective preschool teachers' views regarding the nature of science and scientific inquiry. In service of this goal, answers to the following questions have been sought:

- What are the views of the prospective preschool teachers regarding the nature of science?
- What the views of the prospective preschool teachers on scientific inquiry?
- Is there a statistically significant difference between the prospective preschool teachers' views on the nature of science and scientific inquiry?

Methodology

Examining prospective pre-school teachers' views on the nature of science and scientific inquiry, this study employs a survey model design, which is one of the quantitative research designs (Johnson, 2001; Johnson & Onwuegbuzie, 2004).

The research group of this study consists of 54 fourth grade prospective preschool teachers (32 female, 22 male) studying at the Department of Pre-School Teaching at Firat University Faculty of Education, Turkey, during the 2015-2016 academic year.

This research employed two data collection tools: "Views on Nature of Science" (VNOS-C) to determine prospective pre-school teachers' views on the nature of science and "Views about Scientific Inquiry Questionnaire" (VASI) (Lederman et al., 2014) to explore their opinions about scientific inquiry. VNOS-C was originally developed by Lederman et al. (2002), and was finalized through expert opinions. The Cronbach alpha value of the tool was determined to be .85. VNOS-C includes 10 open-ended questions. It was then adapted to Turkish by Kaya (2010). The second scale, VASI, was adapted to Turkish by the researcher

after permission was received from the original author, and the tool was completed through expert opinion. The scale has seven open-ended questions in total, some of which include more than one sub-question. A pilot study was then performed with eight non-participants of the main study. The pilot revealed that difficulties were experienced in understanding some of the questions. Therefore, short bracketed explanations were included for several items prior to the actual application in the main study. The Cronbach alpha coefficient of the overall scale was found to be .83.

After the questionnaires were applied, individualized semi-structured interviews were administered to each participant in order to determine the conceptual meanings of the prospective teachers related to the nature of science and scientific inquiry. Interview questions were parallel to the questions in the VNOS-C and VASI scales. The researchers mostly focused on the reasons for the responses given by the participants and also on the misconceptions and partial concepts that they could not or did not answer. Interviews lasted approximately 30-45 minutes on average. The interviews were recorded on a voice recorder, then printed and analyzed.

The research data had to be quantitatively transformed in order to statistically distinguish the differences between prospective teachers' views on the nature of science and scientific inquiry. These surveys were often used in the literature to qualitatively assess the participants' perceptions (Lederman et al., 2002; Schwartz, Lederman, & Thompson, 2001). Thus, Lederman was interviewed via e-mail regarding the question of how to evaluate these questionnaires in the quantitative paradigm. It was decided that the assessment should be made separately for each main element in the questionnaire. Based on this proposal, the literature review was conducted and the responses given in the questionnaires were analyzed based on a triple evaluation category. These three categories are designated as "Scientific view," "Partial scientific view" and "Non-scientific view." Each category was scored between 1.0 and 3.5 (Vazquez-Alonso & Manassero-Mas, 1999) by making use of statistical studies after the publication of the questionnaire.

Since the interviews were conducted in a holistic approach parallel to VNOS-C and VASI, the analysis of the survey and interviews was performed holistically. For example, if a prospective teachers scored 1.0 point on the questionnaire made a scientifically sufficient explanation for the same questionnaire during the interview, then the 1.0 point was increased to 3.5 points, or if a teacher candidate scored 0 (zero) points also makes a partial explanation to the same question in the interview, the score obtained from the questionnaire is increased to 1.0 point. However, no prospective teachers received 0 (zero) points in the questionnaire and 3.5 points in the interview.

Pearson Correlation analysis was used to determine whether or not a statistically significant difference exists in terms of prospective preschool teachers' views on the nature of science and scientific inquiry.

Findings

Table 1 and Table 2 depict findings regarding the prospective pre-school teachers' views on the nature of science and scientific inquiry.

Prospective Pre-school Teachers' Views on the Nature of Science

The views of the prospective pre-service teachers on the nature of science were analyzed based on the eight main aspects of the nature of science. Table 1 presents these research findings.

Table 1. Prospective Pre-school Teachers' Views on the Nature of Science

Main Aspects	Scientific View	Partial Scientific View	Nonscientific View
1- Tentative nature of scientific knowledge	0 (0%)	33 (61.11%)	21 (38.89%)
2- Scientific knowledge is experimental	2 (3.70%)	18 (33.33%)	34 (62.96%)
3- Scientific theories and laws	0 (0%)	8 (14.81%)	46 (85.19%)
4- Multiple paths in science	0 (0%)	23 (42.59%)	31 (57.41%)
5- Scientific knowledge is subjective (theory-laden)	0 (0%)	10 (18.52%)	44 (81.48%)
6- Social and cultural embeddedness of science	2 (3.70%)	11 (20.37%)	41 (75.93%)
7- Observation and inference in science	1 (1.85%)	18 (33.33%)	35 (64.81%)
8- Creative and imaginative nature of science	2 (3.70%)	45 (83.33%)	7 (12.96%)

Tentative Nature of Scientific Knowledge: Upon analyzing Table 1, most of the prospective preschool teachers point to scientific knowledge as tentative, yet they have a partial scientific view as they cannot provide satisfactory reasons for these considerations. On the other hand, none of the prospective teachers made scientifically sufficient explanations related to this aspect, while some presented various misconceptions that scientific knowledge is certain with absolute truths and cannot be exposed to change, and so on.

Scientific Knowledge Is Experimental: With regard to this aspect, the vast majority of prospective preschool teachers were identified to have some misconceptions or gave no response about knowledge being certain in the field of science and obtained in the laboratory environment, and that knowledge obtained in the other branches may vary; whereas only two prospective teachers supported their opinions with sufficient justification and examples. Some of the prospective preschool teachers offered a partial scientific view of this main aspect.

Scientific Theories and Laws: Table 1 depicts that the views of prospective preschool teachers are weaker and inadequate in relation to scientific theories and laws compared to

the other main aspects. None of the prospective teachers were found to have scientific views, and that some have numerous misconceptions. For instance, they are of the view that the theory may change if it is to be transformed into a law with full proof, but the laws will not. A few of them presented partial scientific views.

Multiple Paths in Science: Research results revealed that none of the prospective preschool teachers have scientifically adequate views, and most have various misconceptions. They stated that scientists conduct their studies depending on a certain system or stage, and that they have to comply with scientific research steps, and so on. In other respects, some prospective preschool teachers were found to have a partial scientific view since they could not support their views with sufficient reasons and examples.

Scientific Knowledge Is Subjective: Table 1 reveals that only 10 prospective teachers have partially scientific views related to the main element in which scientific knowledge is theory-laden, that is subjective. To illustrate, they emphasized that scientific knowledge is subjective or that scientists studying the same subject can achieve the same or different results due to personal differences. Most of the prospective teachers have remarkable misconceptions based on the ideas that scientific knowledge is absolutely objective, that scientists carry out their studies objectively, and scientific knowledge is precise, etc. Furthermore, no prospective preschool teachers were found with scientific views on this main aspect.

Social and Cultural Embeddedness of Science: Only two prospective preschool teachers presented a scientific opinion supported with sufficient justifications and examples with reference to the relation of science with social and cultural factors. They stated that science and sociocultural values, religious beliefs interact with each other, and that when there is social distress or a problem, scientists conduct research in order to resolve the related problems. All the same, most of them have developed some misconceptions on the ideas that science advances independently of social and cultural values since science is universal and objective. It has also been determined that some prospective teachers have partially presented scientific views.

Observation and Inference in Science: When the views of the prospective preschool teachers were analyzed, many either did not respond or had various misconceptions. On the other hand, some had partial scientific views, and only one teacher presented adequate scientific reasoning to explain his opinion with sufficient justification and examples.

Creative and Imaginative Nature of Science: For this aspect, the prospective preschool teachers were found to be at a better level compared to the other main aspects. Most of the prospective teachers have partial scientific views as they cannot support their views with sufficient justification and examples. For example, many prospective teachers mentioned that scientists use their imagination in their work, that they have a better imagination than other people, and so on. Only two of them made scientifically sufficient explanations related to this aspect, while seven have various misconceptions. To exemplify, some prospective teachers suggested that scientists do not reflect their imagination to a large extent, that scientific knowledge is certain, but science would lose its essence if scientists used their imagination.

Prospective Pre-school Teachers' Views on Scientific Inquiry

The views of the prospective pre-service teachers on scientific inquiry were analyzed based on the eight main aspects, and Table 2 displays these research findings.

Table 2. Prospective Pre-school Teachers' Views on Scientific Inquiry

Main Aspects	Scientific View	Partial Scientific View	Nonscientific View
1- Scientific research starts with a question	0 (0%)	4 (7.41%)	50 (92.59%)
2- Scientists following the same procedure may not achieve same results in scientific research	2 (3.70%)	24 (44.44%)	28 (51.85%)
3- Scientific research process is managed by research questions	3 (5.56%)	15 (27.78%)	36 (66.67%)
4- There are multiple paths in scientific research	0 (0%)	23 (42.59%)	31 (57.41%)
5- Procedures used in scientific research may affect the results of the research.	0 (0%)	11 (20.37%)	43 (79.63%)
6- Results of research should be in accordance with the obtained data	2 (3.70%)	41 (75.93%)	11 (20.37%)
7- Scientific data and scientific evidence are not the same	0 (0%)	18 (33.33%)	35 (64.81%)
8- Explanations on scientific research emerge from blending known and unexamined data in the literature	2 (3.70%)	23 (42.59%)	29 (53.70%)

Scientific Research Starts with a Question: Table 2 suggests that prospective preschool teachers' views related to this aspect are more inadequate than for the other main aspects. A large majority have developed several misconceptions referring to scientific inquiry beginning with curiosity, observation, or need. Furthermore, no prospective teachers could make a scientifically sufficient explanation. However, only four of them were found to have partial scientific views as they could not support their views with sufficient reasons and examples.

Scientists Following the Same Procedure May Not Reach the Same Results in Scientific Research: Only two of the prospective preschool teachers were found to make satisfactory explanations that are scientifically proven. For instance, they are of the opinion that scientists cannot achieve the same result even if they perform the same procedures for the same research question individually, because scientists' judgments, viewpoints, imagination lead them to interpret the results in different ways. On the other hand, some of the prospective teachers have scientific opinions partially due to the fact that they cannot support their views with sufficient reasons and examples, while more than half of them have various misconceptions. To illustrate, some of the prospective teachers emphasized that scientists must achieve the same results as science embodies absolute truths.

Scientific Research Process Is Managed by Research Questions: Most of the prospective teachers were unable to respond or have various misconceptions regarding this main aspect

that investigates how the research process is shaped and which factors lead the research process. Only three prospective teachers were determined to support the idea with reasons and examples, and 15 have partial scientific views.

There are Multiple Pathways in Scientific Research: The findings concerning this major aspect are included in the previous section.

Procedures Used in Scientific Research May Affect the Results of the Research: Dealing with the nature and extent of variables, data collection methods, how data are measured and analyzed, and how these procedures affect the results of the research, this aspect was partially responded to by 11 of the prospective teachers. In addition, none of them held scientific views on this aspect, while the majority have misconceptions indicating that the result must be the same, even though the research procedures change, because the research question is the same.

Results of Research Should Be in Accordance with the Obtained Data: Upon analyzing the findings in Table 2, the prospective preschool teachers' views are seen as satisfactory for this aspect as opposed to the others. Only two of the prospective preschool teachers who offered explanations with reasons and examples have sufficient views that research results should be in accordance with the obtained data, supported by the evidence, etc. Moreover, the majority of have partial scientific views, whereas only some did not respond or had various misconceptions.

Scientific Data and Scientific Evidence are Not the Same: No prospective preschool teachers were found to make a scientifically adequate explanation about the definition of scientific data and whether or not there is a relation between scientific data and scientific evidence. Other than that, it has been determined that some of them candidates did not give an answer or they had numerous misconceptions. For instance, they believe that data and evidence are similar, that data are perceived as quantitative findings, and evidence is proven as definite information. A few of the prospective teachers partially explained data and evidence, yet they could not exactly express the differences between them or present favorable examples.

Explanations on Scientific Research Emerge from Blending Known and Unexamined Data in the Literature: When the views of the prospective teachers were examined, only two were found to have scientific opinions. Nearly half of them were partially scientific, while more than half of the prospective teachers have various misconceptions.

Relationship between Prospective Preschool Teachers' Views on Nature of Science and Scientific Inquiry

A Pearson Correlation analysis was used to identify whether or not there is a relationship between prospective preschool teachers' views on the nature of science and scientific inquiry. The research findings revealed a statistically significant relationship between prospective preschool teachers' views on the nature of science and scientific inquiry ($r=.795$, $p<.05$).

Results and Discussion

Having examined prospective preschool teachers' views on the nature of science and scientific inquiry, the results of the research suggested that their views on the nature of science and scientific inquiry are generally considered to be inadequate. Most of the prospective preschool teachers' may be said to have better views on the main aspects of "scientific knowledge is tentative, imagination and creativity in science" compared to the others. However, most of the prospective teachers were determined to be inadequate in relation to the other six main aspects. As far as scientific research is concerned, most prospective teachers hold only partial scientific views on the main aspect of "research results should be consistent with the obtained data," while they have numerous misconceptions regarding the other seven aspects. Only a few of them have put forward a scientific view on the main aspects of the nature of science and scientific inquiry.

The overall result of the research reveals that prospective preschool teachers' views on the nature of science and scientific inquiry among the most significant characteristics of a scientifically literate person are quite inadequate from the position of raising scientifically literate individuals (Aydemir, 2016). The reasons are thought to be that prospective teachers are inadequately educated particularly about the nature of science and scientific inquiry during their undergraduate education and a lacking in the structure and content of the pre-school teacher's program. Upon examining the pre-school teacher's degree program and course content, it is surprising that there are only two courses (Science Education and Scientific Research Methods) directly related to science among the 60 courses. Moreover, there is no course related to the nature of science within the teaching program.

Although prospective teachers take lessons related to science education and scientific inquiry in the undergraduate education period, interview results have shown that these courses are taught ineffectively. The prospective teachers indicated that science education and scientific research courses are conducted in a way that is far removed from the research-questioning strategy. This may be a contributing reason for which prospective preschool teachers have inadequate views on the nature of science and scientific inquiry. In addition, it is likely that the prospective teachers are trained on the basis of behavioral approach in general, preventing them from designing and implementing appropriate teaching and evaluation activities and from being inadequate regarding the knowledge that a teacher should possess as well as the nature of science and scientific inquiry (Schwartz, et al., 2007).

Similar results emerged in the studies conducted by Aydemir (2016), Senemoglu (2003), and Ozden (2003). As prospective preschool teachers' views on the nature of science and scientific inquiry influence children's opinions (Akerson, Buzzelli, & Donnelly, 2010), prospective teachers' inadequacy related to knowledge and skills may cause serious problems in embedding nature of science and science research topics into their subjects (Capps & Crawford, 2013). It is well known that teachers cannot teach or evaluate subjects / concepts in the absence of full knowledge (Gess-Newsome, 2002; Lederman, 1998, 2007). Therefore, it is paramount in teaching courses through the use of appropriate pedagogical approaches from the perspective of the nature of science and scientific inquiry, and discussing the main elements of the nature of science and scientific inquiry related to science subjects and concepts in an open and reflective way in the undergraduate education

process (Akerson, 2004; Aydemir, 2016; Bell, 2007; Olgan, Guner-Alpaslan, & Oztekin, 2014; Ugras & Cil, 2016). It is also suggested that appropriate learning conditions be established for prospective teachers so that they can effectively integrate the main elements of science with nature and scientific research into their lessons; besides, the restructuring of teacher training programs and education faculties especially on the basis of the nature of science and scientific inquiry is essential (Aydemir, 2016) and it is of great importance to increase the number of courses for these subjects (Bayir & Gunsen, 2014).

Notes

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